CLAIMS

What is claimed is:

1. An oscillator circuit comprising:

a plurality of amplifiers, which also function as impedance buffers;

a first phase-shift circuit connected between the amplifiers, the first phase-shift circuit being capable of adjusting the phase of an oscillator loop;

a feedback circuit, an input side of the feedback circuit being connected to an output terminal of the amplifier that is connected to an output side of the first phase-shift circuit, an output side of the feedback circuit being connected to an input terminal of the amplifier that is connected to an input side of the first phase-shift circuit;

a second phase-shift circuit provided in the feedback circuit, the second phase-shift circuit being capable of adjusting the phase and gain of the oscillator loop; and

a piezoelectric vibrator provided in the feedback circuit,

wherein the second phase-shift circuit and the piezoelectric vibrator are connected in series with each other.

2. An oscillator circuit according to Claim 1, wherein the second phase-shift circuit includes a tank circuit that resonates at an oscillation frequency of the piezoelectric vibrator.

3. An oscillator circuit according to Claim 1, wherein at least one of the first phase-shift circuit and the second phase-shift circuit includes a voltage-controlled

phase-shift circuit capable of adjusting the phase of the oscillator loop in accordance with a received control voltage.

4. An oscillator circuit according to Claim 1, wherein each of the amplifiers is a differential amplifier including an inverting input terminal, a non-inverting input terminal, an inverting output terminal, and a non-inverting output terminal.

5. An oscillator circuit according to Claim 4, wherein the differential amplifier is an emitter-coupled logic circuit.

6. An oscillator circuit according to Claim 1, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

7. An oscillator circuit according to Claim 2, wherein at least one of the first phase-shift circuit and the second phase-shift circuit includes a voltage-controlled phase-shift circuit capable of adjusting the phase of the oscillator loop in accordance with a received control voltage.

8. An oscillator circuit according to Claim 7, wherein each of the amplifiers is a differential amplifier including an inverting input terminal, a non-inverting input terminal, an inverting output terminal, and a non-inverting output terminal.

9. An oscillator circuit according to Claim 8 wherein the differential amplifier is an emitter-coupled logic circuit.

10. An oscillator circuit according to Claim 9, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

11. An oscillator circuit according to Claim 2 wherein each of the amplifiers is a differential amplifier including an inverting input terminal, a non-inverting input terminal, an inverting output terminal, and a non-inverting output terminal.

12. An oscillator circuit according to Claim 11 wherein the differential amplifier is an emitter-coupled logic circuit.

13. An oscillator circuit according to Claim 12, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

14. An oscillator circuit according to Claim 11, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

15. An oscillator circuit according to Claim 2, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

16. An oscillator circuit according to Claim 3, wherein each of the amplifiers is a differential amplifier including an inverting input terminal, a non-inverting input terminal, an inverting output terminal, and a non-inverting output terminal.

17. An oscillator circuit according to Claim 3, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

18. An oscillator circuit according to Claim 4, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

19. An oscillator circuit according to Claim 5, wherein the piezoelectric vibrator is any one of an AT-cut quartz vibrator, a reverse-mesa AT-cut quartz vibrator, and a SAW vibrator.

20. An adjusting method for adjusting the oscillator circuit as set forth in Claim 1, the adjusting method comprising:

a gain and phase calculation step of measuring circuit characteristics of the oscillator circuit and of calculating the gain and phase of the oscillator loop at an oscillation frequency of the oscillator circuit when the piezoelectric vibrator is disposed in gas and when the piezoelectric vibrator is disposed in liquid;

a first phase-adjusting step of changing a circuit constant of the first phase-shift circuit of the oscillator circuit to adjust a phase condition such that the phase is 0 and the gain is 1 or less in a frequency range higher than the principal

vibration frequency except for frequencies near the principal vibration frequency when the piezoelectric vibrator is disposed in gas and when the piezoelectric vibrator is disposed in liquid;

a second phase-adjusting step of changing a circuit constant of the second phase-shift circuit of the oscillator circuit to adjust the phase of the oscillator circuit to approximately 0 degrees at a frequency near the oscillation frequency in a frequency range in which the phase significantly changes when the piezoelectric vibrator is disposed in gas and when the piezoelectric vibrator is disposed in liquid; and

a gain adjusting step of changing the circuit constant of the second phase-shift circuit of the oscillator circuit to adjust the gain of the oscillator loop of the oscillator circuit to 1 or more when the piezoelectric vibrator is disposed in gas and when the piezoelectric vibrator is disposed in liquid.

21. An adjusting method according to Claim 7, wherein, in the gain adjusting step, a negative resistance is set to be at least three times larger than the impedance of the piezoelectric vibrator.

22. An adjusting method according to Claim 21, wherein each of the gain and phase calculation step, the first phase-adjusting step, the second phase-adjusting step, and the gain adjusting step is performed when the oscillator circuit is in an open loop.

23. An adjusting method according to Claim 7, wherein each of the gain and phase calculation step, the first phase-adjusting step, the second phase-

adjusting step, and the gain adjusting step is performed when the oscillator circuit is an open loop.

24. A mass measuring apparatus comprising the oscillator circuit as set forth in Claim 1.